This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

(5)

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 7/26 — A1

(11) International Publication Number: WO 97/24820

(43) International Publication Date: 10 July 1997 (10.07.97)

(21) International Application Number: PCT/US96/20162

(22) International Filing Date: 23 December 1996 (23.12.96)

(30) Priority Data:
08/578,945 27 December 1995 (27.12.95) US

(71) Applicant: ERICSSON INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

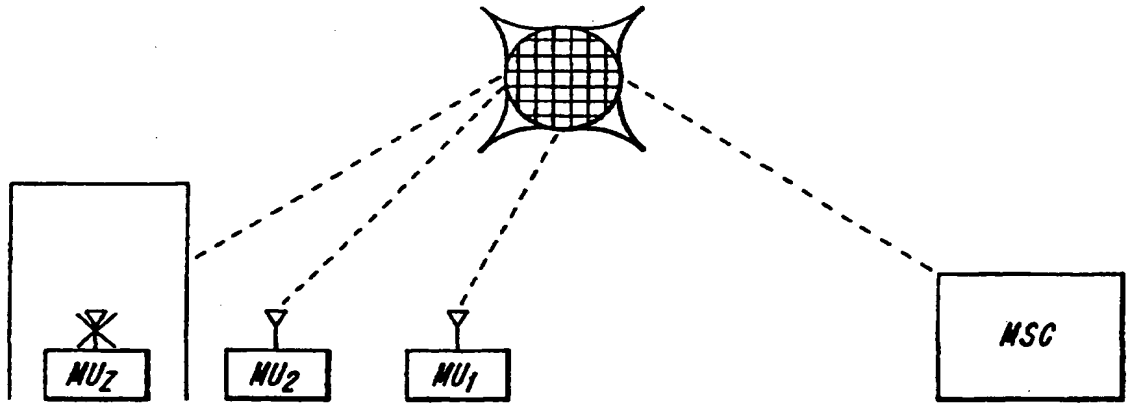
(72) Inventors: CHENNAKESHU, Sandeep; 311 Glen Abbey Drive, Cary, NC 27513 (US). RYDBECK, Nils; 207 Queensferry Road, Cary, NC 27511 (US). HASSAN, Amer, A.; 412 Key West Mews, Cary, NC 27513 (US). DENT, Paul, W.; Stehags Prästgård, S-240 36 Stehag (SE).

(74) Agents: GRUDZIECKI, Ronald, L. et al.; Burns, Doane, Swecker & Mathis, L.L.P., P.O. Box 1404, Alexandria, VA 22313-1404 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: HIGH POWER SHORT MESSAGE SERVICE USING TDMA FRAMES



(57) Abstract

A method and system for transmitting short data messages in a control station-based TDMA radiocommunication system. According to exemplary embodiments, selected TDMA frames are assigned as message frames, and one or more data slots from each message frame are assigned to transmitter/receivers. Data messages can be encoded and transmitted multiple times, at an increased power level, from a control station to a transmitter/receiver over the appropriate data slots in each message frame. The selected TDMA frames are preferably slow associated control channel frames.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgystan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SG	Singapore
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LR	Liberia	SZ	Swaziland
CS	Czechoslovakia	LT	Lithuania	TD	Chad
CZ	Czech Republic	LU	Luxembourg	TG	Togo
DE	Germany	LV	Latvia	TJ	Tajikistan
DK	Denmark	MC	Monaco	TT	Trinidad and Tobago
EE	Estonia	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	UG	Uganda
FI	Finland	ML	Mali	US	United States of America
FR	France	MN	Mongolia	UZ	Uzbekistan
GA	Gabon	MR	Mauritania	VN	Viet Nam

HIGH POWER SHORT MESSAGE SERVICE USING TDMA FRAMES

Field of the Invention

The present invention generally relates to radiocommunication systems and more particularly relates to a system and method for reliably transmitting alphanumeric messages via radiocommunication signals under non-ideal conditions.

Background of the Invention

Referring to Figure 1, a typical cellular mobile radiocommunication system is shown. The typical system includes a number of base stations similar to base station 110 and a number of mobile units or stations similar to mobile 120. Voice and/or data communication can be performed using these devices or their equivalents. The base station includes a control and processing unit 130 which is connected to the MSC (mobile switching center) 140 which in turn is connected to the public switched telephone network (not shown).

The base station 110 serves a cell and includes a plurality of voice channels handled by voice channel transceiver 150 which is controlled by the control and processing unit 130. Also, each base station includes a control channel transceiver 160 which may be capable of handling more than one control channel. The control channel transceiver 160 is controlled by the control and processing unit 130. The control channel transceiver 160 broadcasts control information over the control channel of the base station or cell to mobiles locked to that control channel. The voice channel transceiver broadcasts the traffic or voice channels which can include digital control channel location information.

When the mobile 120 first enters an idle mode, it periodically scans the control channels of base stations like base station 110 for the presence of a paging burst addressed to the mobile 120. The paging burst informs mobile 120 which cell to lock on or camp to. The mobile 120 receives the absolute and relative information broadcast on a control channel at its voice and control channel transceiver 170. Then, the processing unit 180 evaluates the received control

channel information which includes the characteristics of the candidate cells and determines which cell the mobile should lock to. The received control channel information not only includes absolute information concerning the cell with which it is associated, but also contains relative information concerning other cells proximate to the cell with which the control channel is associated. These adjacent cells are periodically scanned while monitoring the primary control channel to determine if there is a more suitable candidate. Additional information relating to specifics of mobile and base station implementations can be found in U.S. Patent Application Serial No. 07/967,027 entitled "Multi-Mode Signal Processing" filed on October 27, 1992 to P. Dent and B. Ekelund, the entirety of which is incorporated herein by reference. It will be appreciated that the base station may be replaced by one or more satellites in a satellite-based mobile radiocommunication system.

To increase radiocommunication system capacity, digital communication and multiple access techniques such as Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), and Code Division Multiple Access (CDMA) may be used. The objective of each of these multiple access techniques is to combine signals from different sources onto a common transmission medium in such a way that, at their destinations, the different channels can be separated without mutual interference. In a FDMA system, users share the radio spectrum in the frequency domain. Each user is allocated a part of the frequency band which is used throughout a conversation. In a TDMA system, users share the radio spectrum in the time domain. Each radio channel or carrier frequency is divided into a series of time slots, and individual users are allocated a time slot during which the user has access to the entire frequency band allocated for the system (wideband TDMA) or only a part of the band (narrowband TDMA). Each time slot contains a "burst" of information from a data source, e.g., a digitally encoded portion of a voice conversation. The time slots are grouped into successive TDMA frames having a predetermined duration. The number of time slots in each TDMA frame is related to the number of different users that can simultaneously share the radio channel. If each slot in a TDMA frame is assigned to a different user, the

duration of a TDMA frame is the minimum amount of time between successive time slots assigned to the same user. CDMA combines FDMA and TDMA. In a CDMA system, each user is assigned a unique pseudorandom user code to uniquely access the frequency time domain. Examples of CDMA techniques include spread spectrum and frequency hopping.

In a TDMA system, the successive time slots assigned to the same user, which are usually not consecutive time slots on the radio carrier, constitute the user's digital traffic channel, which is considered to be a logical channel assigned to the user. The organization of TDMA channels, using the GSM standard as an example, is shown in FIG. 2. The TDMA channels include traffic channels TCH and signalling channels SC. The TCH channels include full-rate and half-rate channels for transmitting voice and/or data signals. The signalling channels SC transfer signalling information between the mobile unit and the satellite (or base station). The signalling channels SC include three types of control channels: broadcast control channels (BCCHs), common control channels (CCCHs) shared between multiple subscribers, and dedicated control channels (DCCHs) assigned to a single subscriber. A BCCH typically includes a frequency correction channel (FCH) and a synchronization channel (SCH), both of which are downlink channels. The common control channels (CCCHs) include downlink paging (PCH) and access grant (AGCH) channels, as well as the uplink random access channel (RACH). The dedicated control channels DCCH include a fast associated control channel (FACCH), a slow associated control channel (SACCH), and a standalone dedicated control channel (SDCCH). The slow associated control channel is assigned to a traffic (voice or data) channel or to a standalone dedicated control channel (SDCCH). The SACCH channel provides power and frame adjustment and control information to the mobile unit.

The frequency correction channel FCH of the broadcast control channel carries information which allows the mobile unit to accurately tune to the base station. The synchronization channel SCH of the broadcast control channel provides frame synchronization data to the mobile unit.

Using a GSM-type system as an example, the slow associated control channel SACCH can be formed by dedicating every 26th TDMA frame to carrying SACCH information. Each SACCH frame includes 8 time slots (1 SACCH slot for each traffic slot in the frame), allowing one unique SACCH channel for each mobile communication link. The base station or satellite sends commands over the SACCH channel to advance or retard the transmission timing of the mobile unit to achieve time alignment between different mobile bursts received at the base station or satellite.

The random access channel RACH is used by the mobiles to request access to the system. The RACH logical channel is a unidirectional uplink channel (from the mobile to the base station or satellite), and is shared by separate mobile units (one RACH per cell is sufficient in typical systems, even during periods of heavy use). Mobile units continuously monitor the status of the RACH channel to determine if the channel is busy or idle. If the RACH channel is idle, a mobile unit desiring access sends its mobile identification number, along with the desired telephone number, on the RACH to the base station or satellite. The MSC receives this information from the base station or satellite and assigns an idle voice channel to the mobile station, and transmits the channel identification to the mobile through the base station or satellite so that the mobile station can tune itself to the new channel. All time slots on the RACH uplink channel are used for mobile access requests, either on a contention basis or on a reserved basis. Reserved-basis access is described in U.S. Patent Application No. 08/140,467, entitled "Method of Effecting Random Access in a Mobile Radio System", which was filed on October 25, 1993, and which is incorporated in this application by reference. One important feature of RACH operation is that reception of some downlink information is required, whereby mobile stations receive real-time feedback for every burst they send on the uplink. This is known as Layer 2 ARQ, or automatic repeat request, on the RACH. The downlink information preferably comprises twenty-two bits that may be thought of as another downlink sub-channel dedicated to carrying, in the downlink, Layer 2 information specific to the uplink. This flow of information,

which can be called shared channel feedback, enhances the throughput capacity of the RACH so that a mobile station can quickly determine whether any burst of any access attempt has been successfully received. As shown in FIG. 2, this downlink information is transmitted on channel AGCH.

Transmission of signals in a TDMA system occurs in a buffer-and-burst, or discontinuous-transmission, mode: each mobile unit transmits or receives only during its assigned time slots in the TDMA frames on the mobile unit's assigned frequency. At full rate, for example, a mobile station might transmit during slot 1, receive during slot 2, idle during slot 3, transmit during slot 4, receive during slot 5, and idle during slot 6, and then repeat the cycle during succeeding TDMA frames. The mobile unit, which may be battery-powered, can be switched off (or "sleep") to save power during the time slots when it is neither transmitting nor receiving.

To increase mobility and portability, radiocommunication subscribers tend to prefer mobile units having a relatively small, omnidirectional (and accordingly, less powerful) antenna over mobile units having a large or directional antenna. Because of this preference, it is sometimes difficult to provide sufficient signal strength for the exchange of communication signals between typical mobile units having a small, omnidirectional antenna and a mobile switching center (MSC) or satellite. This problem is particularly serious in satellite-based mobile radiocommunications.

A satellite-based mobile radiocommunication system provides radiocommunication services to particular geographical areas of the earth using one or more partially overlapping satellite beams. Each satellite beam has a radius of up to about 1000 KM. Due to the power limitations of a satellite, it is not practical to provide a high link margin in every beam simultaneously.

Because mobile satellite links are severely power limited, communication is typically limited to line-of-sight channels with Ricean fading. Ricean fading occurs from a combination of a strong line-of-sight path and a ground-reflected wave, along with weak building-reflected waves. These channels require a communications link

margin of approximately 10 dB or more to achieve voice communication in ideal or near-ideal conditions, such as when the mobile radiotelephone unit antenna is properly deployed and the unit is in an unobstructed location. In these near-ideal channels, the mobile unit can successfully monitor the paging channel to detect incoming calls. In non-ideal conditions, such as when the mobile unit antenna is not deployed or the mobile unit is in an obstructed location (e.g., inside a building) reflected waves, including ground-reflected and building-reflected waves, become dominant. The channels in these non-ideal conditions are characterized by flat Rayleigh fading (the most severe type of fading) with severe attenuation. In such channels, a link margin of as much as 30 dB or more is required to achieve reliable voice or data communication, and the mobile unit in this case cannot monitor the paging channel to detect incoming calls. In these non-ideal conditions, a short message service (SMS) is desirable. Due to the power limitations of the satellite, SMS is particularly effective when used in non-ideal conditions to alert a mobile station user of an incoming call. The mobile station user may then change locations to receive or return the call. The term "link margin" or "signal margin" refers to the additional power required to offer adequate service over and above the power required under ideal conditions- that is, a channel having no impairments other than additive white Gaussian noise (AWGN). "Impairments" include fading of signal amplitude, doppler shifts, phase variations, signal shadowing or blockage, implementation losses, and anomalies in the antenna radiation pattern.

Whether transmitting voice or data, it is frequently desirable to increase the signal margin to ensure reliable radiocommunication performance, particularly in power-limited satellite applications. Known methods of increasing the link margin of a signal include expanding the channel bandwidth to achieve frequency selectivity or to use forward error correction coding (such as convolutional coding), increasing signal power, and bit repetition (which may be viewed as a form of forward error correction coding). Each of these methods has significant limitations. Bandwidth expansion is typically achieved by known methods such as signal spreading and low bit rate error correction coding, and results in a signal which is less sensitive to

fading. Bandwidth expansion reduces spectrum allocation efficiency. Further, in a SMS application, if the expanded bandwidth of the voice channel is different from the bandwidth of the message channel, two separate and complete radios (one for each service) will be required in the mobile unit, thereby complicating its design. Also, a coherent Rake receiver or equalizer is also typically required to reduce delay spread, further complicating the design of the mobile unit. Bandwidth expansion may also be implemented by repeated transmissions of the entire voice or data message. However, under the non-ideal conditions of interest, this method is not effective because each repetition is typically below the noise floor (that is, does not have a sufficient margin), resulting in a high error rate and preventing the coherent integration of the repetitions.

Increasing signal power may also be used to provide a higher margin. Due to the power limitations of the satellite, this is typically not a practical approach. In addition to increasing the cost of the system, increased transmission power also makes it more difficult to control co-channel interference, particularly in TDMA systems with narrow re-use margins. Accordingly, large power increases from the satellite to the mobile unit may be provided only during periods of relatively light use. Further, because the mobile unit is even more power limited than the satellite, this technique is typically practical only in one direction, from the satellite to the mobile unit.

Bit repetition may also be used to increase the margin. Bit repetition results in a lower error rate than message repetition, particularly in non-ideal conditions. Bit repetition causes transmission delay, which is not desirable for voice signals, for obvious reasons. However, transmission delay may be acceptable for data communications, such as a SMS feature, provided that the delay is kept to a reasonable minimum. Bit repetition is achieved by transmitting individual bits or modulation symbols, or packets of bits or modulation symbols, a plurality of times such that all repetitions are contiguous or contained within the same time slot or slots of successive TDMA frames. The receiver integrates the energy from each repetition to create a signal having a higher margin. As noted above, bit repetition

can cause significant delay, depending upon the length of the message. To achieve a 30 dB signal margin, each bit will have to be repeated 1000 times. A typical short message has between 32 and 64 characters in the GSM system, the European digital standard, up to 245 characters in the DAMPS (Digital Advanced Mobile Phone Service) system currently used in the United States, and up to 160 characters in the DECT (Digital European Cordless Telephone) system. Assuming a GSM system having TDMA frames of 18.64 ms, with 16 slots per frame and 114 data bits/slot, the minimum delay for receiving a 64 character message, not including propagation time, is as follows:

64 bits X 8 bits/character X 1000 repetitions/bit X 18.64 ms/slot X 1/114 slot/data bit = 84 seconds.

Such a delay is highly undesirable, even for data transmission. Accordingly, it would be desirable for a radiocommunication system to allow for transmission of signals at an increased signal margin without significant delay and without a significant increase in power.

It would be further desirable for a communication system to allow for transmission of signals with an increased signal margin without requiring expansion of the channel bandwidth.

It would also be desirable for a TDMA communication system to allow for transmission of signals with an increased signal margin without requiring a change in the structure or organization of TDMA frames.

It would be further desirable for a mobile radiocommunication system to allow for transmission of data messages originating from either a mobile unit or from a satellite or base station with an increased signal margin.

It would be further desirable for a communication system to selectively increase the signal margin of a communication link for the transmission of data messages.

While numerous enhancements to TDMA communication systems have been proposed, they do not adequately address the problems noted above. For example, WO 95/31878 discloses a method for increasing the transmission speed of data in

a TDMA system. According to the disclosed method, a high-speed data signal is split into multiple lower speed signals, a mobile station is allocated a corresponding number of time slots from each TDMA frame, and each of the lower speed signals is transmitted over a different one of the allocated time slots. However, this document does not address the transmission of data messages at an increased power level. Further, this document does not address the problem of delivering a message to a shadowed mobile unit in a power limited (e.g., satellite-based) communication system.

WO 95/12931 discloses a method of communicating information to a remote station by grouping time slots into superframes, each superframe including a plurality of paging slots. The paging slots are grouped into a plurality of paging frames for sending messages in successive hyperframes. Each superframe can include time slots comprising a logical paging channel. However, this document does not address the transmission of data messages at an increased power level. Further, this document does not address the problem of delivering a message to a shadowed mobile unit in a power-limited (e.g., satellite-based) communication system.

EP 0 671 824 A1 (SIEMENS) is directed to a method for increasing transmission speed in a digital telecommunication system. According to the method, when a higher transmission speed is required, two or more channels are combined to form a multiple channel which is assigned to the subscriber requiring increased transmission speed. This document does not address the problem of delivering a message to a shadowed mobile unit in a power-limited (e.g., satellite-based) communication system.

Therefore, none of these documents adequately address the problems addressed by the present invention.

Summary of the Invention

The above-noted and other limitations of conventional communication systems and methods are overcome by the present invention, which provides for a

high-penetration transmission method for transmitting short alphanumeric messages in which signal margin is increased by a combination of bit repetition and a relatively small increase in power. According to exemplary embodiments, the combination of bit repetition and a relatively small increase in power avoids the unacceptable delays characteristic of systems which rely solely on repetition to increase the signal margin. Likewise, the combination of repetition and a relatively small increase in power avoids the co-channel interference problems of systems which rely solely on increased power to increase the signal margin.

According to an exemplary embodiment of the present invention, a radiocommunication system is provided with a short message service feature for transmitting alphanumeric messages between a control station, such as a satellite, and a transmitter/receiver, such as a mobile unit. Selected ones of the TDMA frames are assigned as message frames, and each message frame includes a number of data slots for transmitting data messages. In order to ensure reliable transmission over channels having severe attenuation, the data message is encoded; the encoded message is divided into packets or groups of one or more bits each; each packet is transmitted, at a power level greater than the power level for voice transmission, multiple times over the data slots of the message frames, using the same time slot or slots for each transmission to a particular subscriber; and the transmissions are integrated and checked for errors at the receiver to form a signal having an increased margin.

Brief Description of the Drawings

The foregoing objects, features and advantages of the present invention will be more readily understood upon reading the following detailed description in conjunction with the drawings in which:

FIG. 1 is a block diagram of an exemplary mobile radiocommunication system;

FIG. 2 is a diagram showing the organization of channels in a typical GSM digital radiocommunication system;

FIG. 3 is a diagram of a satellite-based mobile radiocommunication system in which the signal transmission method of the present invention may be implemented;

FIG. 4 is a flow chart describing the transmission of a short message according to an embodiment of the present invention; and

FIG. 5 is a diagram showing the format of an SMS frame according to an embodiment of the present invention.

Detailed Description of the Preferred Embodiments

While the following description is directed toward a short message service implemented in a satellite-based radiocommunication system incorporating satellites and mobile radiocommunication units, it will be appreciated that the present invention may also be applied to other types of communication systems which include suitable transmitter/receiver units.

In a satellite-based mobile radiocommunication system, a communication link for transmitting voice or data may be established between a mobile station and either a standard telephone or a second mobile station through one satellite, multiple satellites, or a combination of one or more satellites and the PSTN (public switched telephone network). Such a system, as shown in FIG. 3, may be desirable to achieve a broad geographical coverage in which few or no base stations are present, and additional base stations are not practical, such as in rural areas. Due to the inherent power limitations of satellites, voice communications links between the satellite and the mobile station require ideal or near-ideal conditions; that is, conditions such as line-of-sight communication with the mobile station's antenna properly deployed. In non-ideal conditions, such as when the mobile station is shadowed (e.g., inside a building, etc.) or when the mobile antenna is not properly deployed, the power or signal margin requirements for communication increases significantly due to the increased attenuation in the channel. In such situations (shown as MUz in FIG. 3), Rayleigh fading often prevents satisfactory communication, and it is therefore desirable to send a short alphanumeric message to the mobile station. The message may be used, for example, to inform the

subscriber of an incoming call. The present invention ensures reliable transmission of the message by providing for an efficient technique for increasing signal margin without significant delay, power increase, or co-channel interference.

For purposes of illustration only, and without limiting the scope of the invention, a satellite-based GSM radiocommunication system using TDMA channels may be assumed to exhibit the following conditions. The communication channel has no line of sight component and is subject to flat Rayleigh fading with severe attenuation. As will be appreciated by those of skill in the art, Rayleigh (or multipath) fading is a phenomenon which occurs when multipath waves form standing-wave pairs due to reflection from the physical structures in a service area. The standing-wave pairs summed together form an irregular wave fading structure. When the mobile unit is stationary, it receives a constant signal. However, when the mobile unit is moving, the fading structure causes fading to occur which increases as the mobile unit moves faster. The mean signal level of the non-ideal Rayleigh channel is approximately 20-30 dB below the signal level of a near-ideal line-of-sight channel.

In order to ensure reliable transmission of a short message to the mobile unit in non-ideal conditions, the signal margin must be increased. According to the present invention, bit repetition and power increase can be combined to provide an increased signal margin without significant delay.

It will be appreciated that decibels (dB) are units used to express ratios of power, current, or voltage. Specifically, a power ratio (P2/P1) may be expressed in decibels by the formula $dB = 10 \log (P2/P1)$. A signal margin of 30 dB requires a power ratio of 1000, since $10 \log 1000 = 30$. Thus, to achieve this signal margin solely by bit repetition, each bit must be repeated 1000 times and the signal margin from each repetition must be integrated at the receiver, resulting in the 82 second delay calculated above. However, to achieve a 15 dB margin, the required power ratio is only 31.623, since $10 \log 31.623 = 15$. Thus, a 30 dB signal margin may be provided by increasing the power by 15 dB and repeating each bit approximately 31 times. Using this technique, the bit-repetition delay for a 64 character message

is (64 characters X 8 bits/character X 31 repeats/bit X 18.64 ms/slot X 1/114 slot/bits) approximately 2.5 seconds. As a result, the bit repetition delay is maintained at a reasonable level, and the power increase is also maintained at a reasonable level, thereby avoiding co-channel interference. It will be appreciated that many different combinations of repetitions and power increases are possible to achieve successful communication in Rayleigh fading environments without significant delay. Further, rather than repeating individual bits of a digital signal, groups of bits may be repeated.

To implement the technique of the present invention, the power increase from the satellite to the mobile station may be provided by averaging a power load across multiple users. That is, communication channels used by mobile units in near-ideal conditions might have their power reduced to increase the power supply to a mobile unit or units in the non-ideal conditions. Power increase may also be provided by time averaging, in which individual slots in consecutive TDMA frames are transmitted at an increased power level. It will be appreciated that the power increase from the satellite to the mobile station may also be achieved by other techniques known in the art.

The power limitations of the mobile unit are even more severe than the power limitations of the satellite. Thus, it is even more difficult to increase power for communication from the mobile to the satellite. Such communication is necessary to send a message or acknowledge receipt of a message. According to one embodiment of the present invention, the power increase from the mobile unit to the satellite may be achieved by allowing the mobile unit to transmit on all time slots of the random access channel RACH. Bit repetition may also be implemented by the mobile unit to further effectively increase the margin of the signal transmitted to the satellite. Since acknowledgement by the mobile unit over the RACH channel may be accomplished by a signal having a low information rate, a higher number of sync bits and a higher number of bit and message repetitions relative to the forward channel can be used to compensate for the lower transmission power of the mobile unit. Preferably, the mobile unit transmits consecutive repetitions on

separate carrier frequencies to decorrelate the repetitions. Because the message is short, the transmission time will be short and the average transmitted power will be acceptable using this system.

Referring now to FIG. 4, a flow chart describing the transmission of a short message using the transmission method of the present invention is shown. Referring now to FIG. 4, a flow chart describing the transmission of a short message using the transmission method of the present invention is shown. In step 100, a sending party inputs a message to be transmitted to a receiving subscriber. The message may be input into the communication system directly by the sending party through a mobile unit, a standard telephone, a computer terminal, or equivalent device, or the message may be input indirectly by calling an operator at a service center who inputs the message into the system. In step 102, the information bits comprising the short message are encoded by an encoder located at the transmitter with an error detection code, such as CRC. The encoded message constitutes one or more codewords, each containing codeword bits or symbols. It should be recognized that the transmitter may be the satellite, a base station, or a mobile unit. In step 104, bit repetition can be employed, such that each of the codeword bits or symbols output by the encoding means are repeated N times to form a packet containing N bits. It will be apparent that, instead of repeating individual bits or symbols, groups of two or more bits or symbols, or the entire codeword or codewords could also be repeated. Packets are then transmitted such that each slot within a TDMA frame includes one or more packets of repeated bits, error detection coding bits, and a sync burst to enable the receiver to estimate the channel quality. All bits comprising the encoded short message are transmitted in this fashion. If bit repetition and message repetition are employed, once the entire encoded message has been transmitted, the transmission of the message (in the form of packets of N codeword bits) can be repeated M times to achieve the desired signal margin. It will be appreciated that, since the short message may be transmitted from a satellite, base station, or mobile station, encoding and transmitting functions are provided in each of these devices. It will also be appreciated that, in order to implement the technique of the present invention, means

are included in the transmitter to determine the number of bit repetitions N, message repetitions M, and power increase necessary to achieve the signal margin required for successful transmission of the message.

In step 108, the receiving device (i.e., the mobile unit, satellite, base station, or equivalent device) samples the received signal, including the repeated encoded message bits, error detection bits, and channel quality estimation bits, and generates a metric sum of the form $Y_j = \sum_{i=1}^{N} |r_{ij} - \hat{C}_j S|^2$, where r_{ij} is the sampled received signal corresponding to the ith repetition of the information bit or symbol S in packet repeat j, and C_j is the corresponding estimate of channel quality. In step 110, a decoder contained in the receiving device decodes each encoded bit or symbol in the TDMA slot from the metric sums, using soft combining or majority logic voting, or other suitable decoding methods. To implement soft combining, the decoder adds metric sums as $Y = \sum_{j=1}^{M} Y_j$ and makes a bit or symbol decision based on the sum. To implement majority logic voting, the decoder makes a preliminary bit or symbol decision for each metric y_j and then a makes a final bit or symbol decision by comparing all of the preliminary decisions. Thus, if the decoder has made M preliminary decisions, the decoder will determine that the corresponding information bit is a 1 if more than half of the preliminary decisions were 1; otherwise, the decoder will determine that the corresponding information bit is a 0. The same logic is used to decode a bit that is a 0. To prevent an error which might result if exactly half of the preliminary decisions are 0 and exactly half of the preliminary decisions are 1, M is chosen to be an odd number. The decoded bits are combined coherently and the multiple transmissions of the message are combined coherently to generate a message signal having an increased margin.

In step 112, an error detector contained in the receiving apparatus detects errors based on the CRC error detection coding provided at the transmitting apparatus. If no errors are detected, the message is displayed on the receiving subscriber's mobile unit in step 114. If an error is detected, then the message is not displayed at the receiving apparatus, the user is notified of an erroneous message by a displayed error message or by an audio signal, and the receiver requests the

transmitter to retransmit message or the erroneous parts of the message in accordance with a bidirectional radio protocol described in more detail below.

According to the present invention, repeated transmission of messages may be used in combination with repetition of individual portions of a message. That is, individual portions of the message may be transmitted multiple times, and when the entire message has been transmitted by means of the repeated transmissions of the message portions, the entire message may be transmitted again.

To implement a satellite-based mobile communication having a SMS feature according to the present invention, a message channel is formed by "stealing" or borrowing frames from the slow associated control channel SACCH. For example, the transmitter can assign every 8th frame of the SACCH channel for use as a message frame to carry SMS information; this implementation would provide one SMS frame for each 104 regular TDMA frames, or one SMS frame approximately every 1.92 seconds. It will be appreciated that by using every eighth SACCH frame, the SACCH date rate is reduced by one-eighth, which does not adversely affect the system. In the SMS channel, an exemplary frame format is shown in FIG. 5, and includes two forward correction channel (FCH) slots, two idle slots, two synchronization channel (SCH) slots, two additional idle slots, and 24 data slots, for a total of 32 slots for each SMS frame. The 24 data slots are used to transmit message information. Each one of the 24 data slots is assigned to a corresponding mobile unit, such that each subscriber receives one data slot per SMS frame. Thus, the data slot or slots in each message frame which are assigned to a particular subscriber's mobile unit constitute a message channel for that subscriber. It will be appreciated that alternate frame formats may be used, and that multiple data slots may be assigned to each mobile unit. Further, frames other than the SACCH frames may be used as message frames.

An encoder in the satellite suitably encodes message data. Bit and/or message repetition, in combination with increased transmission power, can also be implemented by the transmitter, as described above. Preferably, in this SMS implementation, each bit is transmitted three times, each message or portions thereof

are transmitted three times, and the SMS frames are transmitted at approximately 6 dB more power than the voice frames and slots of the TDMA communication link. 104 frames, or approximately 1.92 seconds, are required for synchronization in this embodiment. Since one active SMS frame occurs for each 104 TDMA frames in this embodiment, the duty cycle is approximately 1%.

Because the short message service is implemented by using the relatively infrequent stealing or borrowing of frames, it will be appreciated that the satellite or cellular system is not significantly affected in an adverse way.

While the foregoing description includes numerous details and specificities, it is to be understood that these are merely illustrative of the features and principles of the present invention, and are not to be construed as limitations. Many modifications will be readily apparent to those of ordinary skill in the art which do not depart from the spirit and scope of the invention, as defined by the following claims and their legal equivalents.

CLAIMS:

1. A method for transmitting a data message between a control station and a transmitter/receiver in a TDMA communication system in which a TDMA communication channel is established at a first power level between the control station and the transmitter/receiver, comprising the steps of:

assigning one or more frames from the TDMA communication system as message frames, each message frame including a plurality of data slots; and

transmitting the data message to the transmitter/receiver at a second power level higher than the first power level over one or more of the data slots of each of the message frames.

2. The method of claim 1, wherein each message frame further includes forward correction channel slots, synchronization channel slots, and idle slots.

3. The method of claim 1, wherein each message frame is a slow associated channel frame of the TDMA communication system.

4. The method of claim 1, wherein the step of transmitting is performed a plurality of times.

5. The method of claim 4, wherein the step of transmitting is performed three times.

6. The method of claim 1, wherein each data slot in each message frame is assigned to a different transmitter/receiver.

7. The method of claim 1, wherein each data slot includes a plurality of data bits, the data codeword includes message bits, and each message bit is specified by a plurality of data bits.

8. The method of claim 1, further comprising the step of encoding the data message with error detection coding prior to the step of transmitting.

9. A TDMA communication system, comprising:

means for establishing a TDMA communication channel at a first power level between a control station and a transmitter/receiver, the TDMA communication channel including one or more time slots from each of one or more TDMA frames;

means for assigning selected TDMA frames as message frames, each message frame including a plurality of message slots; and

means for transmitting a data message to the transmitter/receiver at a second power level higher than the first power level over one or more of the message slots in each message frame.

10. The system of claim 9, wherein each message frame further includes forward correction channel slots, synchronization channel slots, and idle slots.

11. The system of claim 9, wherein each selected message frame is a slow associated channel frame.

12. The system of claim 9, wherein the data message is transmitted a plurality of times.

13. The system of claim 12, wherein the data message is transmitted three times.

14. The system of claim 9, wherein each data slot in each message frame is assigned to a different transmitter/receiver.

15. The system of claim 9, wherein each data slot includes a plurality of data

bits, the data message includes message bits, and each message bit is specified by a plurality of data bits.

16. The system of claim 9, wherein the data message is encoded.

17. The system of claim 16, wherein the data message is encoded with CRC error detection coding.

18. A method for transmitting data messages in a TDMA communication system, comprising the steps of:

assigning a plurality of TDMA frames as message frames, each message frame including a plurality of data slots, wherein one or more of the data slots from each message frame are assigned as a separate communication channel for each of a plurality of transmitter/receivers, and wherein the remainder of data slots from each frame carry communication information transmitted at first power level; and

transmitting a data message over each separate communication channel at a second power level higher than the first power level.

19. The method of claim 18, wherein each message frame further includes forward correction channel slots, synchronization channel slots, and idle slots.

20. The method of claim 18, wherein each message frame is a slow associated channel frame.

21. The method of claim 18, wherein the step of transmitting is performed a plurality of times.

22. The method of claim 21, wherein the step of transmitting is performed three times.

23. The method of claim 18, wherein each data slot in each message frame is assigned to a different transmitter/receiver.

24. The method of claim 18, wherein each data slot includes a plurality of data bits, the data message includes message bits, and each message bit is specified by a plurality of data bits.

25. The method of claim 18, further comprising the step of encoding each data message with error detection coding.

FIG. 1
PRIOR ART

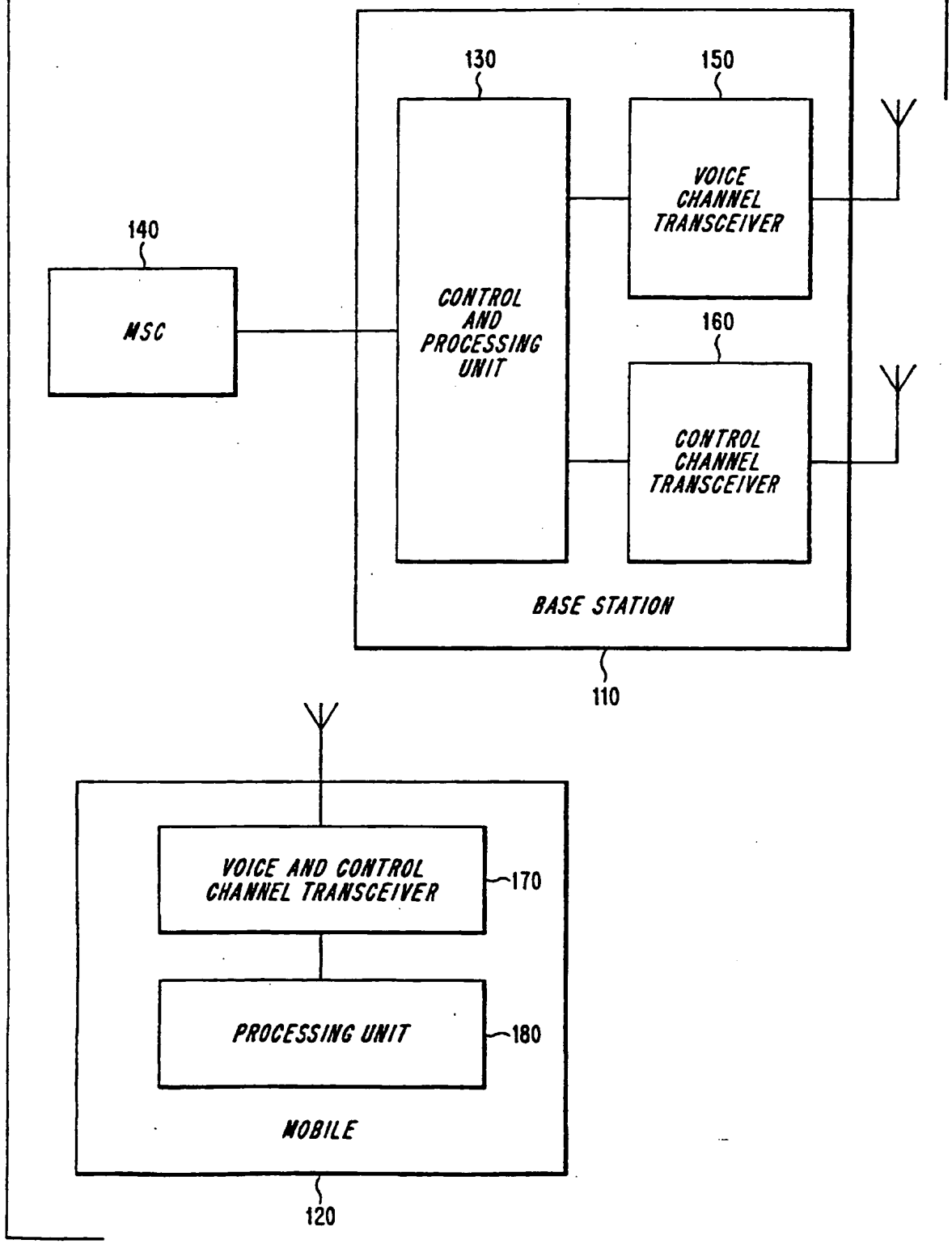
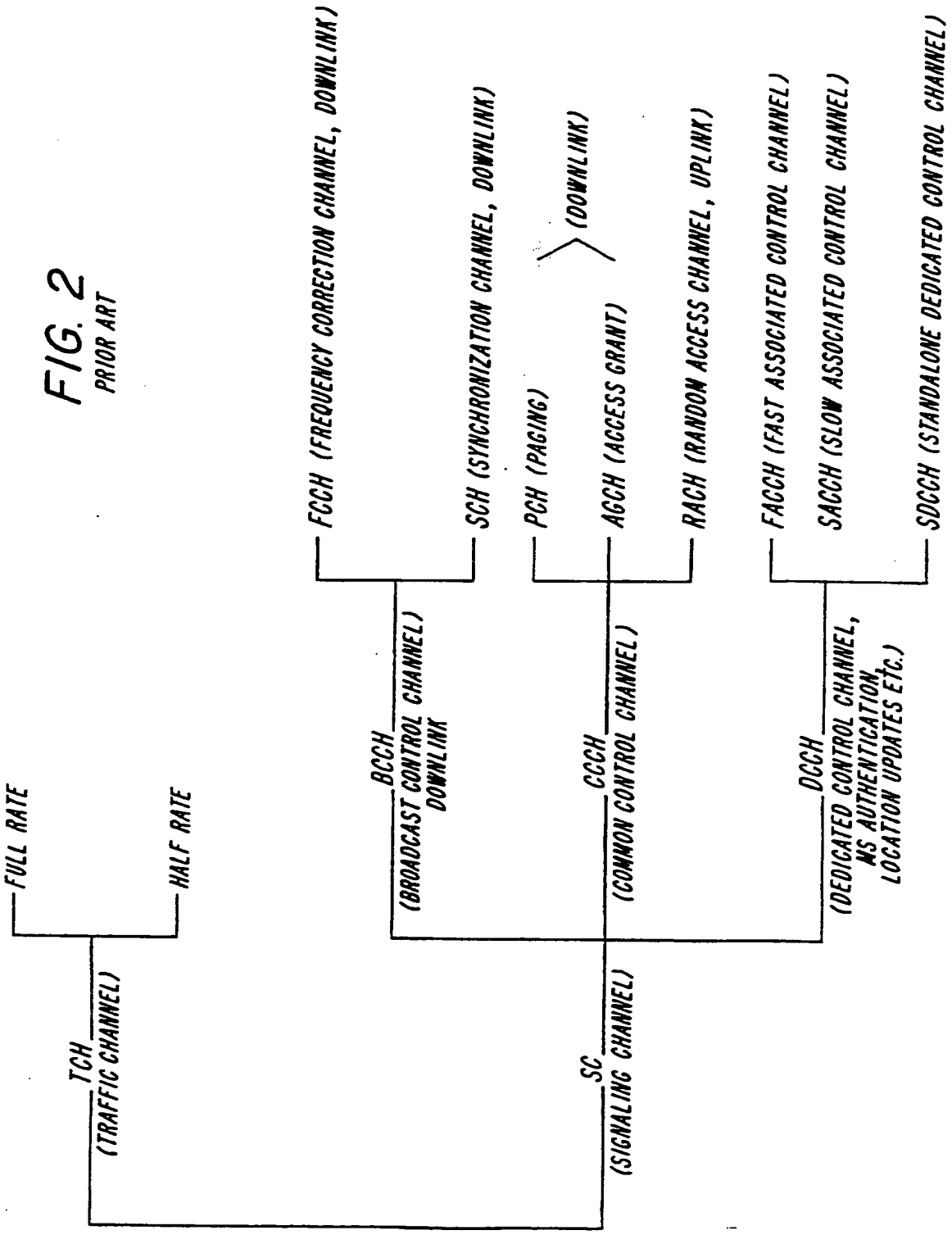


FIG. 2
PRIOR ART



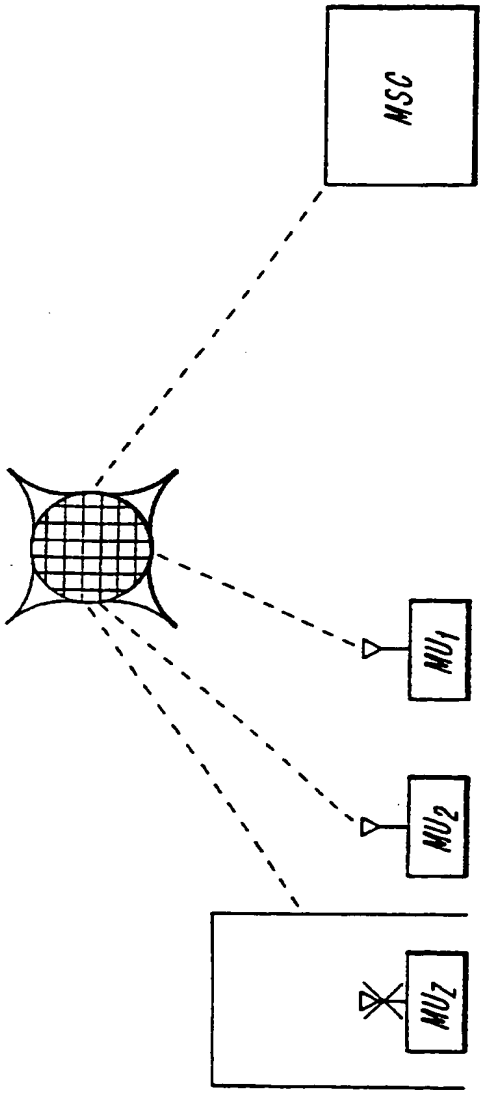

MSC
MU1
MU2
MU2

FIG. 3

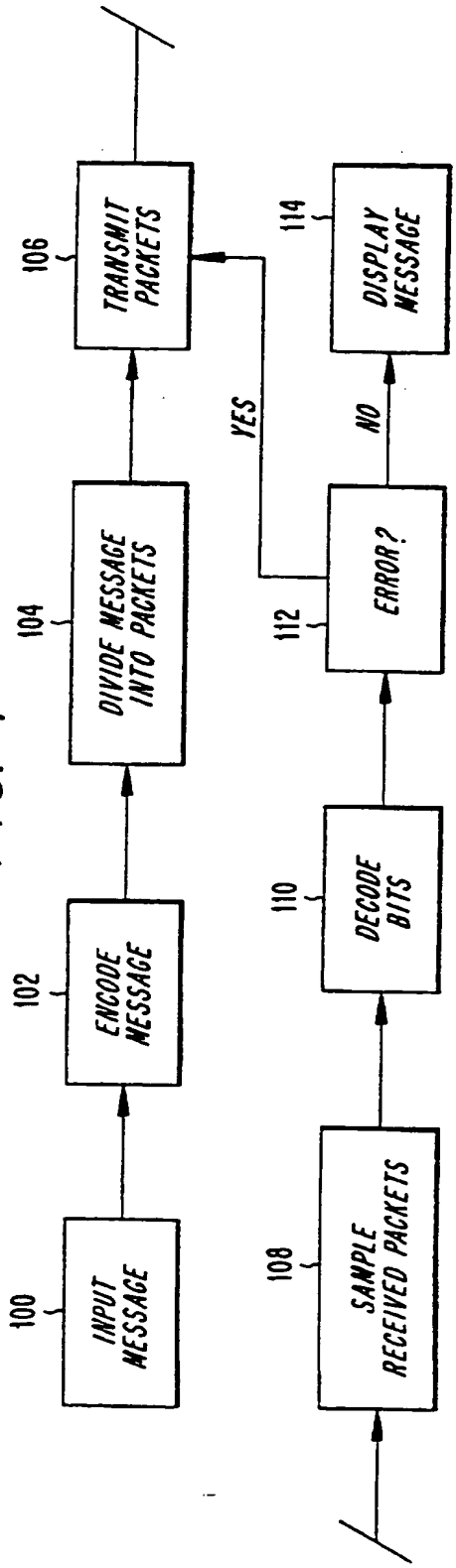
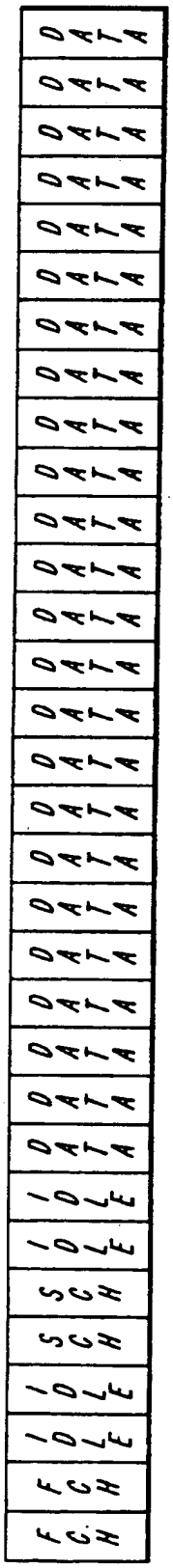

100
INPUT MESSAGE
102
ENCODE MESSAGE
104
DIVIDE MESSAGE INTO PACKETS
106
TRANSMIT PACKETS
108
SAMPLE RECEIVED PACKETS
110
DECODE BITS
112
ERROR?
YES
NO
114
DISPLAY MESSAGE

FIG. 4

FIG. 5


FCH
FCH
IDLE
IDLE
SCH
SCH
IDLE
IDLE
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA
DATA

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 96/20162

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B H04N H04J H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 96 04718 A (QUALCOMM INCORPORATED) 15 February 1996 see page 7, line 10 - line 15 see page 3, line 20 - page 4, line 26; claims 1-47; figures 1-3	1-25
X	WO 95 31878 A (NOKIA) 23 November 1995 see claims 1-13	1-25
X	WO 95 12931 A (ERICSSON) 11 May 1995 see page 12, line 15 - page 14, line 29	1-25
X	EP 0 671 824 A (SIEMENS) 13 September 1995 see claims 1-25; figures 1-36	1-25
A	EP 0 535 812 A (NOKIA) 7 April 1993 see page 2, column 2, line 37 - page 3, column 4, line 38	1-25

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
4 April 1997	28. 04. 97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Bischof, J-L

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 96/20162

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 94 13113 A (NOKIA) 9 June 1994 see page 3, line 20 - line 35	2,10,19
A	EP 0 565 507 A (ERICSSON - GE MOBILE COMMUNICATIONS INC.) 13 October 1993 see page 3, line 10 - line 55	7,17,25

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Intern ...al Application No
PCT/US 96/20162

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9604718 A	15-02-96	AU 3093695 A	04-03-96
		CA 2169649 A	15-02-96
		CN 1130963 A	11-09-96
		EP 0721704 A	17-07-96
		FI 961414 A	20-05-96
		ZA 9505940 A	01-02-96
WO 9531878 A	23-11-95	FI 942190 A	12-11-95
		AU 2410395 A	05-12-95
		NO 964747 A	08-11-96
WO 9512931 A	11-05-95	US 5603081 A	11-02-97
		US 5604744 A	18-02-97
		AU 1048095 A	23-05-95
		AU 1048395 A	23-05-95
		AU 1087495 A	23-05-95
		AU 1087695 A	23-05-95
		AU 7757094 A	18-05-95
		AU 8131394 A	23-05-95
		AU 8131494 A	23-05-95
		BR 9404316 A	04-07-95
		BR 9405702 A	28-11-95
		BR 9405703 A	28-11-95
		BR 9405704 A	28-11-95
		BR 9405705 A	28-11-95
		BR 9405743 A	05-12-95
		BR 9405927 A	05-12-95
		CA 2134695 A	02-05-95
		CA 2152942 A	11-05-95
		CA 2152943 A	11-05-95
		CA 2152944 A	11-05-95
		CA 2152945 A	11-05-95
		CA 2152946 A	11-05-95
		CA 2152947 A	11-05-95
		CN 1112345 A	22-11-95
		CN 1117329 A	21-02-96
		CN 1116888 A	14-02-96
		CN 1117330 A	21-02-96
		CN 1117331 A	21-02-96
		CN 1124074 A	05-06-96

INTERNATIONAL SEARCH REPORT

...formation on patent family members

Inter nal Application No
PCT/US 96/20162

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9512931 A		CN 1117332 A	21-02-96
		EP 0652680 A	10-05-95
		EP 0682829 A	22-11-95
		EP 0679304 A	02-11-95
		EP 0677222 A	18-10-95
		EP 0681766 A	15-11-95
		EP 0677223 A	18-10-95
		EP 0677224 A	18-10-95
		FI 953262 A	30-08-95
		FI 953263 A	30-06-95
		FI 953264 A	30-06-95
		FI 953265 A	30-06-95
		FI 953266 A	30-06-95
		FI 953267 A	22-08-95
		FI 953268 A	30-06-95
		JP 8510607 T	05-11-96
		JP 8508627 T	10-09-96
		JP 8508628 T	10-09-96
		JP 8508629 T	10-09-96
		JP 8508630 T	10-09-96
		JP 8508631 T	10-09-96
EP 671824 A	13-09-95	FI 951051 A	08-09-95
EP 535812 A	07-04-93	GB 2260244 A	07-04-93
		JP 5219025 A	27-08-93
		US 5384782 A	24-01-95
WO 9413113 A	09-06-94	FI 925448 A	31-05-94
		AU 669038 B	23-05-96
		AU 5564094 A	22-06-94
		EP 0626122 A	30-11-94
		JP 7503593 T	13-04-95
		NO 942836 A	29-09-94
		US 5479410 A	26-12-95
EP 565507 A	13-10-93	AU 4280693 A	18-11-93
		BR 9305478 A	11-10-94
		CA 2111000 A	28-10-93
		JP 8502151 T	05-03-96

INTERNATIONAL SEARCH REPORT

ormation on patent family members

Internal Application No
PCT/US 96/20162

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 565507 A		NZ 252801 A	25-09-96
		WO 9321692 A	28-10-93
		US 5430760 A	04-07-95